Monthly Manager Moments – Article #18

3rd in the pool operation series: Pool Chemicals – what is used and why

Overview of pool chemicals – although there are quite a number of chemicals commonly used for swimming pool operation, there are just a few reasons for them. Let's look first at why we use the various chemicals, and then which ones fulfill those purposes.

Reason #1 – Oxidation and sanitization: Some chemicals do one or the other, and some (like chlorine) do both. We have already discussed oxidation in the previous article. To review, it means elimination of unwanted pathogens and organic compounds that can make you sick, or cause eye and skin irritation. Combined chlorine is the #1 enemy of pool operators in maintaining proper pool chemistry. Proper oxidation is required to eliminate and prevent combined chlorine. Oxidation is measured in ORP, or Oxidation Reduction Potential. Our target is 850-855 mV ORP. This level of ORP can maintain continuous breakpoint oxidation; and pristine water. High ORP is the key to pristine, sparkling water. In our state chlorine can be maintained at 1.5-10.0 PPM, with combined no more than 50% of the total chlorine tested.

Reason #2 – pH control: Of all the variables in pool chemistry, pH is THE most important one to control and maintain at a relatively low level. I recommend 7.3-7.4, and no higher. 7.3 is better than 7.4, because the lower the pH, the more oxidation you can achieve at the same chlorine level. Washington State DOH allows a minimum pH of 7.2.

Reason #3 – Alkalinity control: Total Alkalinity (TA) is basically a measure of the sum of the basic compounds in the water. The target range for TA is 80-120 PPM, with 100 PPM our ideal.

Reason #4 – Hardness control: Calcium Hardness, or just hardness, is a measure of the mineral content of the water. Too low will result in water that is aggressive or corrosive. Too high will result in scaling. Our target here is 300 PPM.

Reason #5 – Temperature: Although chemicals don't change the temperature of your pool, the pool's temperature changes the amount of chemicals that you use. The higher the temperature, the higher the water balance index, called the Calcium Saturation Index or CSI. CSI involves reasons 2-5. Each plays a role in the overall balance of the water to prevent scaling or corrosion. This is really important for the people who operate spas that are 104° as compared to a pool that is around 83°. Because of the high temperature in a spa, the other values must be lowered to maintain the same balance. Target values for a spa might be: 104°, 80 TA, 240 CH, 7.3 pH. This is the set of target values used at EWU Aquatic Center: pH = 7.3; CH = 300; TA = 100; Temp = 82°. These two sets result in a CSI of 0.0, or "perfect balance."

Specific chemicals for each purpose –
#1 – sanitizing and oxidizing: Chlorine is the most common chemical for these two and comes in a variety of forms –

- gas (the pure stuff, 100% chlorine);
- calcium hypochlorite, also called granular chlorine (65-70% chlorine);
- sodium hypochlorite or bleach, also called liquid chlorine (12-13% chlorine);
- lithium hypochlorite (35% chlorine) – another granular and cost prohibitive;
- trichloroisocyanuric acid, also called trichlor, or stabilized chlorine (90% chlorine);
- dichloroisocyanuric acid, also called dichlor (56-60% chlorine), another "stabilized chlorine."
- NaCl (salt) – an ionizing chamber breaks the salt apart, allowing the Cl atom to attach to the water molecule H-OH and form HOCl. Salt pools make chlorine.

Each of these chlorine sources has a different effect on the water's chemistry. Some are acidic, some are basic. Some can actually reduce ORP instead of increasing it! Today, the two most commonly used forms of chlorine are **calcium hypochlorite** (cal-hypo) and **sodium hypochlorite** (bleach). They both have a basic pH effect. Cal-hypo has an 11.8 pH effect, whereas bleach has an effect of 13.0! Since our pH target is just 7.3, these forms of chlorine usually require acids to counter their undesirable pH effect. High pH = low ORP. That's the undesirable effect.

EWU has **gas chlorine**, which is the "old school" form. When the EWU Aquatic Center was built in 1979-80, gas was the chlorine form of choice. Since then, gas has steadily declined to almost zero use, due to its toxicity, requirements for special training, and equipment needed for safe use. Also, supply is an issue. Some chemical companies won't supply gas for pool use anymore, even though it's by far the cheapest, and meets health code. Here, we have both the expert handers and the equipment for safe use. Due to its acidic nature, gas is a great choice for EWU. The water used to fill our pool is very basic, and has very high alkalinity. High alkalinity makes the basic fill water hard to correct. To drive alkalinity down to the desired level of about 100 PPM, acid is needed. Gas chlorine forms two acids when in contact with water: hydrochloric acid (HCl) and hypochlorous acid (HOCl). Because of gas chlorine's powerful negative pH effect, it makes sense to use it here. HOCl is the end product of every chlorine source, because it's "free chlorine." That's the unstable form that is free to sanitize and oxidize effectively.

OK, what about the other forms of chlorine? **Lithium hypochlorite** is rarely used, due to cost. **Salt** IS a chlorine source, via ionization of the NaCl compound. So, a "salt pool" has chlorine; it's just manufactured on site. These pools are different, however; because the need to seed the pool with commercial pool salt. The salt water provides a constant source for the ionizer to break the salt molecule into sodium (Na) and chlorine (Cl) atoms. As with all other chlorine sources, the chlorine atoms provided by the source will combine with water molecules to make HOCl, or free chlorine. Salt pools feel different, and are generally described as “slicker” and are more buoyant than other pools. They are also very salty tasting, of course. Salt pools have issues with Total Dissolved Solids (TDS) accumulation, which can adversely affect the water balance and clarity. But, with proper oxidation and filtration, pristine water can still be had.

Stabilized chlorine (containing cyanuric acid)-

Trichlor and dichlor are heavily used in the hotel/motel/home markets, and at times too often in commercial pools. Why do I say “too often?” Because the stabilizer contained in these two chlorine forms actually reduces ORP dramatically, by making the HOCl more stable. It’s the instability of HOCl that makes it a terrific oxidizer. That’s the same reason that ozone (O_3) is such a terrific oxidizer – it’s VERY unstable and wants to be O_2 again. What?? Why stabilize the chlorine if that makes it ineffective? Because of sunlight. UV rays dissipate HOCl. The sunnier the weather, the worse it is. Outdoor pools in the summer need stabilizer to retain chlorine, but not too much. That’s the key – a little is a good thing; but too much is very bad indeed. If you have cyanuric acid/stabilizer in your pool, test for it and keep the level below 20 PPM. Higher than 20 PPM reduces ORP dramatically by making the chlorine TOO stable. Do not fall for the statement: “you need 70 PPM to attain 100% retention.” Why? Because you’ll have about 95% retention at 20 PPM and still some ORP to oxidize combined chlorine. At 70 PPM cyanuric, your ORP may be so low that you won’t even kill the bacteria, let alone oxidize the combined chlorine. So what do you do? Use cal-hypo instead of trichlor or dichlor and buy the pure granular cyanuric acid. Carefully calculate the cyanuric dosage and keep your level under 20 PPM. You’ll be a happy camper!

Other oxidizers and sanitizers –

I already mentioned **ozone or O_3**. The instability of ozone makes it a very powerful oxidizer and sanitizer, much more so than chlorine. It is not legal for a stand-alone sanitizer because it’s so unstable that it has virtually no residual. Ozone will not exist longer than about 22 minutes without becoming good old oxygen again. So, what is it used for? A secondary oxidizer, AKA chlorine enhancer. Ozone is commonly used to do the work, and chlorine just provides the required residual. Like chlorine, **bromine** is another halogen element that can be used for an oxidizer and sanitizer. It has less than half of the power of chlorine, however, so the cost to do the same thing is much higher. That’s why you rarely see bromine in a commercial pool. It’s more commonly used in small pools or spas, where the water volume is much lower. The most popular oxidizer now being installed is **Medium Pressure UV**. **Amalgam Low Pressure UV** is also becoming popular. These two forms of ultraviolet light kill bugs and oxidize very well, plus they are not chemicals at all, so they have no role in the pool chemistry. **Potassium monopersulfate** (or MPS) is a non-chlorine oxidizer that does not sanitize, but breaks up combined chlorine quite well. A more recent oxidizer, called **peroxolytes** is more powerful than MPS, and far more unstable. There are other chemicals that can provide oxidation or sanitization, but none that are widely used for pools. Remember that all chemicals have other effects on the chemistry, namely the pH. These effects must be countered to keep the parameters where they belong.

#2 – pH control: pH control is accomplished with acids and bases. When using an oxidizer or fill water that has high pH, acids are needed to keep the pH down to around 7.3. These are usually **muriatic acid** (diluted hydrochloric), **carbonic acid** (CO_2 mixed with water), **sulfuric acid**, or **sodium bisulfate** ("dry acid"). Bases used to counteract gas chlorine or trichlor include - soda ash (**sodium carbonate**), caustic soda (**sodium hydroxide),** or baking soda **(sodium bicarbonate**). Baking soda is used more commonly for alkalinity increase than pH increase.

#3 – Alkalinity control: **sodium bicarbonate**, just mentioned is the one chemical used for alkalinity increase. Any strong acid can be used to decrease it. Carbon dioxide can actually have an increasing effect on alkalinity if conditions are right.

#4 – Hardness control: to increase the hardness, **calcium chloride** (ice melt) is used. To lower the hardness, dilution is used. There is no chemical that "neutralizes" hardness.

Others: **Sodium thiosulfate** is used to neutralize chlorine. **Enzymes** are used to eat oils and organic junk. **Polymers** are used to stick tiny material together so it can be trapped in the filter or fall to the bottom. Diatomaceous Earth (DE) is used to coat filters.

Had enough!?? Me too! Actually, I love pool chemistry, and find the relationships between all the factors fascinating and challenging. As an operator myself, that's a good thing!

If you'd like to become an operator yourself, take the AFO course being offered here this year. The first one is October 14-16 Fri/Sa/Su, and the second one is during EWU's Spring Break.

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